Arsenic Mitigation In Bangladesh
A Household Labor Market Approach

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Basic Story Line

- Dramatic reductions in morbidity and mortality related to water borne biological pathogens were achieved in Bangladesh in 1980’s and 1990’s by switching from surface water sources to tube wells.

- Freed women from carrying water.
Over 9 million tube wells were drilled
- Vast majority were shallow (10 to 70 meters)
- Low technology solution
- Now serve over 95% of rural population
- UNICEF and other aid organizations encouraged and helped finance
Unfortunately, water from many of these wells were later found out to be contaminated with arsenic

- Low level arsenic poisoning builds up in human body
- Causes a wide range of health problems
  - Effects occur over 10 to 30+ year time horizon
  - Initial symptoms: lethargy, sores on feet/hands, headaches
  - Longer term symptoms: various forms of cancer, organ failure

The World Health Organization calls the arsenic drinking water contamination in Bangladesh “the largest mass poisoning of a population in history”
Purpose and Main Findings

- This paper looks at the impact of arsenic exposure in rural Bangladesh on household labor supply.

- Overall effects
  - Relative to zero baseline, arsenic contamination associated with ~8% reduction in household labor hours.

- Within household substitution
  - Prime age males work relative more, females less.
Where Does This Fit in the Economics Literature?

- Environmental economists have long estimated health impacts of exposure to hazardous environmental contaminants

- Debate over whether environmentally related health effects have sizeable influence on economic development

- Interest in how adverse shocks impact households in developing countries
Shocks to Household Welfare

- Most work in developing countries has focused on short duration shocks
  - Weather shocks to production
  - Acute illness
- Most relevant of this line of work looks at impacts on household including substitution within a household
  - Pitt and Rosenzweig (IER, 1990)
- Some work beginning on shocks with long term impacts
  - Largely motivated by AIDS in Africa
    - Zivin, et al. (JPubE, 2009)
Arsenic in Bangladesh Groundwater Wells

- Widespread arsenic contamination discovered in large scale survey of wells done by British Geological Survey (2001)
  - Our sample average arsenic concentration 62 \( \mu \)g/liter
    - Our sample range [0.3 to 421]
    - WHO standard 10 \( \mu \)g liter; Bangladesh standard 50 \( \mu \)g liter
  - 57 million people exposed to WHO standard or greater
Econometric Identification Strategy

- Arsenic contamination function of geological conditions

- Use data from time period before widespread knowledge of arsenic contamination in specific well

Our Dataset

• Merge takes place at thana level—5th order subdistrict small enough that BGS levels highly correlated with actual exposure but large enough that households ~independent
  • 220 thanas each with 20 sampled households
  • A few areas not sampled by BGS (e.g., close to Burma)

• Bangladesh
  Division→Area→Region→District→Thana→Union→Village→Household

• 4,259 households after a small amount of data cleaning
Household Hours Worked (HHW)

- Labor hours recorded for any type of remunerated work
- Each household member
- Paid in money or in-kind/household farm or firm
  - Hours “worked” at home not recorded

- Approach taken
  - Add together labor hours supplied by each house member
  - Use household demographic characteristics as regressors
    - Number of member in each sex/age category
    - Other household demographics variables
Choice of Modeling Framework

- Nature of Dependent Variable
  - Non-negative by definition
  - Upper-end of hours worked for households with large number of members quite large but finite

- These suggests survival model framework with number of hours worked as “time” variable

- Most commonly used is Cox Proportional Hazard Model
Cox Proportional Hazard Model

- Allows arbitrary (non-parametric) baseline hazard
  - Hazard function $h(t) = f(t)/S(t)$, where $S(t) = 1 - F(t)$

- Basic model:
  - $h(HHW_i \mid X_i, AS_i) = h_0(HHW) \exp(\alpha AS_i + \beta X_i)$, where
    - $HHW_i$ is household hours work, $X_i$ demographic composition of household, $AS_i$ is arsenic level
    - Coefficient of 1 for $[\alpha, \beta]$ indicates no shift in baseline $h(t)$
      - Smaller than 1 indicates upward shift in HHW (more hours)
      - Larger than 1 indicates downward shift in HHW (less hours)
Base Model (Arsenic Excluded)
Pattern of Demographic Results

- Increase in HHW for females 6-25, particularly pronounced for 16-25 age group

- Increase in HHW for males of all ages starting with [6-10]
  - HHW roughly constant from 16-55, enormously significant

- Quadratic with acres

- HHW goes up with assets, down with Max house educ.
Adding Arsenic

- Linear term only: 1.0108 (t=6.45)

- Quadratic specification
  - Linear: 1.0226 (t=4.59)
  - Quadratic: 0.9996 (t=-2.50)

- HHW is decreasing in arsenic but at a slowly decreasing rate

- Turning point is at ~300 μg (3% of data beyond that point) and at ~580 μg in specification with interactions
Predicted Effect on HHW

- Reducing arsenic level to zero
  - Increase HHW by 7.9%

- Reducing arsenic to WHO standard (10 μg)
  - Increase HHW by 6.5%

- Reduce arsenic to Bangladesh standard (50 μg)
  - Increase HHW by 3.6%
Compensation mechanisms

- Given overall arsenic reduction, more work by prime age males, less by females
  - Reduces loss of income

- Physical assets decrease arsenic related loss in HHW

- Land assets increase arsenic related loss in HHW

- Max household education increases arsenic related loss in HHW
Summary

- For poor in many places, labor hours main asset

- Bangladesh in 2000 ideal for examining the impact of large scale low level chronic health problems induced by exogenous and unknown arsenic exposure

- Estimated effect large, 7.9% reduction HHW